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Crustal structure of Axial Volcano on the Juan de Fuca Ridge, from seafloor depths to the bottom of the magma chamber, using Elastic Full Waveform Inversion.

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Axial volcano is located at 46˚N, 130˚W at the intersection of the Juan de Fuca Ridge and the Cobb-Eickelberg seamount chain. It is the most recent eruptive center of the Cobb hotspot, which last erupted in 2011. The volcano rises ∼700 m above the adjacent ridge axis and its summit features a 8-km-long, U-shaped caldera with an opening to the southeast where there is an active hydrothermal field and very young lava flows. Located at the junction of a mid-ocean ridge and a volcanic hotspot, Axial volcano is atypical and its internal structure remains poorly understood.

Here, we present results from an elastic full waveform inversion (FWI) along multiple seismic lines that span the whole volcano. We have used a multi-stage FWI, inverting successively wide-angle reflections and refractions arrivals from downward extrapolated streamer data, then windowed short offset reflections from the underlying magma chamber. Our final models show fine scale velocity structures with spatial resolutions of tens of meters. Our results indicate that Layer 2A thickness is extremely heterogeneous (350-900 m) within the volcano with abrupt vertical offsets of >300 m at the caldera walls, consistent with faulting of a geologically defined Layer 2A. Interestingly, Layer 2A appears to be extremely thin beneath the active hydrothermal field, where sheeted dikes might lay <100 m beneath the seafloor. On the other hand, the ever-dropping floor of the caldera appears to be a perfect trap for the ponding of lava flows: the thickness of the lava flows increase gradually to the northwest reaching ∼450 m at end of the caldera. Surface velocities are low and exhibit limited variation over the whole volcano suggesting relative recent formation, as layer 2A velocity increases rapidly with age at slightly greater depths. Crustal aging (increase in layer 2A velocity with age) appears to be controlled by pipe-like pattern of focused hydrothermal mineralization. Finally, RTM images reveal a large melt body beneath the caldera, orientated in the same direction and extending to the southeast. The magma body is approximately 14 km long and 3 km wide. In places a pair of vertically offset reflection are imaged, which interpreted as top and bottom reflections would mean a magma body up to 1 km thick.